Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 06, June-2023

Review of Engineering Education in Ethiopia to Implement CDIO Curriculum System

Assefa Maereg Ambelu
(Ph.D. candidate in Tianjin University of Technology and Education)

Houjun Qi
(Professor of Manufacturing Engineering in Tianjin University of Technology and Education)

Dong Xian Hui
(Professor of Vocational education in Tianjin University of Technology and Education)

Abstract -*Curriculum outlines what the aim of education should be, what should be included in it, how and when it should be delivered, and how to assess its performance and consider ways to improve the entire educational process. Any curriculum creation process aims to answer questions such as how a curriculum is created, executed, and assessed, as well as who is involved, and what processes and procedures are used the successful deployment of CDIO requires both top-down and bottom-up approaches. To ensure that the institutional vision and educational development objectives are in sync, the management team may decide to apply the CDIO framework and the top-down methodology. On the other side, challenges to implementing CDIOs include a shift in faculty mindset, conflict, and duplication of work in terms of national accreditation and qualification criteria. To solve these problems, the bottom-up strategy is suggested. With the involvement of faculty members, members of the program committee, and department heads, the changing process increases an internal motivation, a strong commitment, ownership, and value of CDIO.*
Key Words: - curriculum, Higher education, Ethiopia, Engineering education, CDIO, Curriculum Design,

INTRODUCTION

This part deals with the review of literature related to higher education particularly geared to engineering education and its curriculum development process. It begins with the concept and issues of higher education and higher education curriculum development in general and continues to deal with the specific issues related to the issues and concepts of engineering education and curriculum development. Kelly (2004) posits that “one family of issues we must concern ourselves with is that of the lessons which have been learned from the many attempts which have been made to change the curriculum” (Kelly, 2004: 11-12). The review, in general is divided into three major parts. The first part, deals with an overview of the concepts and issues involved in higher education. The second part deals with the concepts and issues related to engineering and curriculum development. Finally, the third part deals with an overview of the development of the education system in Ethiopia.

IDEA OF CURRICULUM SYSTEM

Curriculum is one of the important concepts in higher education that helps to put the idea of higher education into practice (Barnett, 2009; Barnett & Coate, 2005: 5). Curriculum is regarded as a "academic plan" at the college level, implying a deliberate planning process that focuses attention on important educational considerations (Lattuca & Stark, 2009: 4), which will vary by field of study, instructors, students, and institutional goals (Lattuca & Stark, 2009: 4). Curriculum outlines what the aim of education should be, what should be included in it, how and when it should be delivered, and how to assess its performance and consider ways to improve the entire educational process. Any curriculum creation process aims to answer questions such as how a curriculum is created, executed, and assessed, as well as who is involved, and what processes and procedures are used (Ornstein and Hunkins, 2009: 15; McKernan 2008: 4).

According to UNESCO, "the history of engineering, technical applications, and invention encompasses the majority of the broader history of civilization, economic and social interactions" (UNESCO, 2010: 30). The Stone Age, Bronze Age, Iron Age, Steam Age, and Information Age, according to UNESCO, are all related to engineering and innovation that impacted human connection with the world. In addition to its developmental duties, engineers are now expected to handle the large-scale pressing difficulties that societies around the world are confronting. Crawley, et al. 2007: 11) define a professional engineer as "one who has attained and continues to enhance technical, communications, and human relations knowledge, skills, and attitudes, and who contributes effectively to society by theorizing, conceiving, developing, and producing reliable structures and machines of practical and economic value." Concern about undergraduate engineering education, as well as the curriculum development process and its practices, refers to laying the groundwork for the preparation of the underlying requirements, which means developing and equipping individual learners to be able to know, understand, and act effectively in engineering thinking, design, and the production of improved artifacts and modern services

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 06, June-2023

using science and mathematics to improve human life. Engineering education as part of higher education, as well as the curriculum development process and practices related with it at various levels, occupy one of the important places as a way of meeting such expectations (Maraghy, 2011: 11, UNESCO Expert Group, 1995:1).

HIGHER EDUCATION

Some scholars claim that higher education as a field of study is a "relatively new concept" (Noumi, 2007: 3) which does not encompass a specific body of knowledge and which may be considered as a multidisciplinary subject. Higher education mostly refers to the kind of education provided within or under the settings of universities and colleges. Huber and Harkavy (2007) stipulate that 'The University of the Twenty-first Century is both the essential agent and the distinctive servant of democracy. It is the agent, because its continuing activities nurture deliberation and promote the democratic spirit. It is the servant because, at its best, each of the members – faculty, staff, students, alumni –dedicates his or her professional skills to serving the wider common goal (Huber and Harkavy (2007: 42).

In other words, Giroux (2015) contends that higher education "must be widely understood as a democratic public sphere- a space in which education enables students to develop a keen sense of prophetic justice, claim their moral and political agency, utilize critical analytical skills, and cultivate an ethical sensibility through which they learn to respect the rights of others" (Giroux: 110).

These days, many people attend higher education more than ever. Meyer, Francisco, Richard, and Boli-Bennett (1977), in their cross-national study of tertiary enrollment ratios from 1950 to 1970, found very rapid increases in enrollments in all types of countries. Any institution of higher education is a community dedicated to the pursuit and dissemination of knowledge, the study and clarification of values and to the advancement of the society and its services.

Higher education curriculum around the world is witnessing a significant shift in its expectations to help address immediate and longer-term sustainable development challenges. The sector of higher education, at present, is facing a new era of different reforms and concerns about the quality of education in its institutions and it has become a pressing need for states and society since these institutions are aimed at preparing suitably qualified graduates that have the skills and competencies required by the labor market. Quality in higher education is also believed to be "a multidimensional concept, which should embrace, all its functions, and activities: teaching and academic programs, research and scholarship, staffing, students, buildings, facilities, equipment, services to the community and the academic environment" (UNESCO, 1998b).

Curriculum development is a key educational process for educational developers for schools and for higher education (HE) as it allows an educational course to be designed to meet defined needs. Curriculum development cycles in Higher Education Institutions (HEIs) have in general become more rapid due to many factors including competition between institutions and the expectations of government, employers and students that higher educational program will provide the most contemporary knowledge in a particular discipline (Roffe, 2010). Since the end of the Second World War, there has been a growing demand to widen access to higher education and change the elitist nature of universities (Guri-Rosenblit, & Sebkova, 2004: 41). This implies that higher education curriculum has to be directed towards meeting societal needs and aspirations in every case. However, it is argued that education cannot be value-free and different value systems or ideologies generate different types of curricula.

The present universities situated all over the world by large have their roots back in the medieval European historical origin and hence "face common contemporary challenges" (Altbach and Davis,). The profound change that became a reality in higher education in the past two decades had made those to grapple with the implications of these changes. Academic institutions and systems have faced pressures of increasing numbers of students and demographic changes, demands for accountability, reconsideration of the social and economic role of higher education, implication of the end of the cold war and the impact of new technologies among others. In other words, the shape and the size of the national higher education systems, as rightly pointed out by Teichler (2004) "are on the crossroads of external expectations and internal dynamics of higher education and are shaped by legitimate influences and interests of society at large" (Teichler, 2004: 2).

The mission of higher education includes educating, training, and undertaking research (UNESCO 1998). If not the latter, the concept of 'educating' and 'training' obviously entail the use of curriculum because there is no formal education and training which assumes the functioning of an educational institution without the use of some kind of curriculum. Karseth (2006) points out that there are different stakeholders at the international, national and institutional scene: hence, curricular questions are positioned on a "macro", "meso" and "micro" level and represent contesting and conflicting perspectives (Karseth, 2006).

Irrespective of the bases on which higher education rests and the purposes assumed to it including the efforts made to improve it, it seems that the results are not to the level of satisfaction envisioned by those who are involved in it. For instance, At present," one of the mechanisms underlying policy convergences is the shift in many countries from an emphasis on social or mixed social and economic purposes for education, to predominant economic emphasis" (Ball, 1999).

Curriculum in Higher Education

Even though there is a wide recognition of higher education as an important undertaking in every society and the subsequent growth and development in the infrastructure that allowed and gave opportunity for many people to join it, in many parts of the world, "there is little talk about the curriculum in higher education" (Barnett & Coate, 2005: 1). While the term curriculum is familiar in school education, it seems more ambiguous in its usage in higher education context. As pointed out by Hicks (2007), it is a term given very

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 06, June-2023

little currency. "What students should be experiencing is barely a topic for a debate". What building blocks of their courses might be and how they should be put together are even more absent from the general discussion (Barnett & Coate, 2005: 1). To Barnett and Coate "the very idea of curriculum is pretty well missing". Although it is frequently used in academic staff discussions, policy and planning documents, and to describe advisory bodies, its usage is inconsistent and multifarious (Fraser & Bosanquest, 2006) and it seems that the meaning of such a well-used word shifts across contexts.

Karseth (2006) views the curriculum in higher education as a social construction where the process of decision-making is seen as socio-political and a cultural process, and contends that "curriculum as a field of study has not played a central role in the research literature on higher education in Europe" (Karseth, 2006: 256). In the United States, at the program level, undergraduate curricula typically consist of three to four components i.e., general or liberal studies, major specializations, which are prescribed by the particular department or program offering the specialization (Spink & Mal, 2013: 33). On the other hand, in professional faculties such as engineering or law, the major and minor fields may be governed by the curricular prescription of the professional field represented or by guidelines extended by the disciplinary associations, or by state licensure requirements or professional board examinations.

In connection with college education, Lattuca and Stark (2009: 4) define the term curriculum as an "academic plan", which implies deliberate planning process that focuses attention on important considerations, and which will vary by field of study, instructors, students, instructional goals and other things. In other words, curriculum, in the context of higher education, is viewed as "the formal academic experience of students pursuing baccalaureate and subordinate degrees" (Clark & Neave, 1992:1566). According to Clark and Neave, undergraduate curriculum is formalized into courses or programs of study including workshops, seminars, colloquia, lecture series, laboratory internship, and field experiences. Course, in this sense, generally refers to designate a formal unit of undergraduate curriculum. These authors also contend that the organization and structure of higher education curriculum is significantly influenced by the historical, social, political and economic contexts of each country in the face of the debate concerning what should be the purpose, content, and structure of undergraduate curriculum. The debate, however, varies in meaning and direction between the developed and the less developed nations. However, within higher education, a faculty member, who organizes a course that refers to a formal unit of undergraduate program, generally controls the purpose, process, and content. Similarly, Ratcliff (1997) defines 'undergraduate curriculum' as "the formal academic experience of students pursuing baccalaureate and less than baccalaureate degrees. Such a curriculum is formalized into courses of programs of study including workshops, seminars, lecture series, laboratory work, internships, and field experiences (Ratcliff, 1997:6)."

This means that the term curriculum in higher education is used either in a limited 'content' focused discussion or it is used as a vehicle for discussion of a particular issue. However, there are definitions of the term 'curriculum' specifically geared to the situation in higher education. For instance, Fraser and Bosanquest (2006), in their study that included 25 interviews found that the term curriculum is conceptualized at four categories:

- Category A: The structure and content of a unit (subject);
- Category B: The structure and content of a program of study;
- Category C: The students' experience of learning;
- Category D: A dynamic and interactive process of teaching and learning.

According to these researchers, categories of understanding A and B they conceptualize the curriculum as a product that can be defined and then recorded on paper. These views of curriculum focus on what the teacher as an individual teaches to students, that is, a unit or subject, but also may incorporate the whole program of study undertaken by a student. In category C understanding curriculum is conceptualized as a process and structure that enable student learning, and category D views curriculum as a dynamic, emergent and collaborative process of learning for both students and teachers. The researchers, using the Habermas's theory of 'knowledge-constitutive interest', as expounded by Cornbleth (1999), Grundy, (1987) and Kemmis and Fitzelarence (1980) also analyzed the curriculum in view of technical interest, practical (communicative) interest, and an emancipator interest.

Curriculum Development in Higher Education

Postmodern curriculum development in higher education is not seen as permanent but as creative and fluid (Oliver & Hyun, 2011) and it does not focus on specific steps in curriculum development but instead on the relationships of people involved in the process of creating curriculum (Tierney, 1989). Higher education curriculum has historically been considered the work of the faculty. More recently, however, external influences such as society, government, alumni, and others are affecting curriculum development and the curricular change process (Stark & Lattuca, 1997, pp. 98-100).

These days, accreditation bodies expect more from higher educational institutions especially in the area of assessment of student learning in many countries. Such external influence has caused a number of educational institutions to engage in curricular review in an effort to identify the desired student learning outcomes (Alstete, 2004; Lucas, 2000; Wolf & Hughes, 2007). External influences such as Washington Accord (WA) (1989), which is involved in the accreditation of qualifications in professional engineering, the Sydney Accord (SA) (2001) which recognizes equivalence in the accreditation of qualifications in engineering technology, The Dublin Accord (DA) (2002), which is involved in the accreditation of tertiary qualifications in technician engineering can be cited as

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 06, June-2023

examples of major influences in this regard.

Curriculum in higher education is usually adapted rather than adopted (Lindquist, 1978 in Clark & Neave 1992: 1574). This is done by any faculty who manage to identify the difference (gap) between what the current curriculum provides and what they think it should provide to the student.

Curriculum Models in Higher Education

As it has been pointed out earlier in this study, the way we conceive the term curriculum determines how curriculum is developed and who is involved in the curriculum. For example, Bergquist (1977), based on the rational perspective of curriculum, identified the following curricular models in higher education:

1. Heritage based: A curriculum designed to inculcate students with a knowledge of the past
2. Thematic Based: a specific problem (such as the environment) is identified and studied in-depth.
3. Competency Based: students learn specific skills such as proficiency in language and mathematics.
4. Career Based: the curriculum is designed to prepare students for a specific career.
5. Experience Based: Opportunities are created for the student to learn outside of the classroom.
6. Student Based: the curricular emphasis is on providing students with opportunities to control what they learn.
7. Value Based: The curriculum emphasizes specific institutional values
8. Future Based: the institution divides the curriculum with a concern for what students will need in the future (Bergquist, 1977: Cited in Tierney, 1995: 35)

Curriculum making, in any way, is not a linear process (Karseth, 2006: 278). A piece of change effected at one level has consequences on other levels, which goes beyond those that are intended to be achieved at the end. However, It has been argued that higher education rests upon two curriculum models, that is , 'the disciplinary model', and the 'vocational/professional model' (Karseth, 2006: 257). According to Karseth, the disciplinary model has been dominant in university curriculum, although with important exceptions and the vocational model has been traditionally linked to the college sector and undergraduate professional programs. A summary of the disciplinary curriculum model is provided by Karseth (2006) in the following table, (Table 1).

Table 1 disciplinary curriculum

disciplinary curriculum	
driving force: the knowledge production itself	
structure	the disciplines situated in departments subjects offered on foundational intermediate and graduate level
content	disciplinary knowledge emphasis on cognitive coherence
pedagogy	subject based teaching vertical pedagogic relations
aims	content driven aims, mastery of conceptual structures, methods and modes of arguments

Source: Karseth (2006;259)

As pointed out by Karseth (2006), in the disciplinary discourse the main educational pillar is the knowledge structure of the discipline. The central aim is the apprenticeship into conceptual structures and modes of arguments. Hence, education implies a strong emphasis on students' acquisition of theoretical knowledge.

On the other hand, Karseth (2006) contends that the discourse shaping the vocational curriculum model is enunciated by stakeholders who emphasize that education should be an apprenticeship into specific knowledge domains in order to develop specific skills relevant for specific professions as summarized in the following table, (Table 2)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 06, June-2023

Table 2: vocational curriculum

disciplinary curriculum	
driving force: The need of trained employees for human service, information and production (social legitimation)	
structure	Unified cumulative programs Regulated by national core curricula
content	Multi-disciplinary knowledge emphasis on the integration of theory and practice
pedagogy	Teacher based / subject based teaching apprenticeship vertical pedagogic relation.
aims	Vocational driven aims mastery of specific skills and a shared knowledge repertoire

Source: Karseth (2006;259)

According to Karth (2006), the dominant discourses in higher education up to now can be characterized by the two models presented above. Nevertheless, models other than these two also become part of the discourse in higher education. The multidisciplinary model (Jarning, 2012) in this sense can be seen as an effort to balance professional and disciplinary knowledge cultures. Nevertheless, the two models, that is, disciplinary model, and the vocational/professional models, are being challenged by models such as the multidisciplinary model and by a credit accumulation and transfer discourse advocating global competition and European cooperation (Karth, 2006). As mentioned, modularization is a key characteristic. Its function is to disaggregate traditional extended higher education courses; the specification of outcomes allows modules to be evaluated against each other for the purpose of equivalence. Ensor (2004) argues that the specification of learning outcomes in the credit exchange discourse is not first of all an effort to address issues of quality. It is an attempt to provide mechanism to facilitate the circulation of knowledge in an organized framework.

ENGINEERING EDUCATION

Engineering education, irrespective of its peculiar characteristics, as part of higher education, shares much of the common attributes discussed in connection with curriculum and curriculum development, especially as related to higher education. The Merriam Webster Dictionary defines the term “engineering” in various ways, one of which is “the activities or function of engineer”, where an engineer is defined as “designer or builder of engines” or “a person who is trained in or follows as a profession a branch of engineering”. Engineering is also understood as the application of science to the optimum conversion of the resource of nature to the uses of humankind (Smith, 1962).

Engineering, in the sense of UNESCO is the field of discipline, practice, profession and art that relates to the development, acquisition and application of technical, scientific and mathematical knowledge about the understanding, design, development, invention, innovation and use of materials, machines, structures, systems, and processes for specific purposes (UNESCO, 2010). Engineering and technology are critical inputs for economic development and competitiveness hence, a nation’s educational program should, among other things, be aimed at solving the problems facing the nation and improving the economy through wealth creation (Luiz, et al. 2004).

Higher education institutions, in general, are required to educate and train personalities who would be able not only to think individually and creatively but also to act successfully and compete individually or in groups in both national and foreign labor market. Engineering education as part of higher education occupies one of the central positions in such expectations. Concern about engineering education obviously entails the preparation and equipping of young people to be able, understand and act effectively in the design and production of improved artifacts and modern services through the use of science and mathematics to make the human life easier and comfortable and to contribute to the future development of the engineering profession within the society into which it is provided and beyond.

Engineering and engineering curriculum within higher education system are also perceived in different ways by different people. Dym, Gogino, Eris, Frey and Leifer, (2005), for instance, associate engineering education with graduate engineers “who can design, and that

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 06, June-2023

design thinking is complex". These authors consider design as the central or distinguishing activity of engineering and that engineering programs should graduate engineers who can design effective solutions to meet social needs. The definition they provide for engineering design is as follows: "Engineering design is a systematic, intelligent process in which designers generate, evaluate, and specify concepts for devices, systems, or processes whose form and function achieve clients' objectives or users' needs while satisfying a specified set of constraints (Dym et. al, 2004: 309).
According to Dym et al, design problems reflect the fact that the designer has a client (or customer) that, in turn, has in mind a set of users (or customers) for whose benefit the designed artifact is being developed. Mourtos, (2013) also considers design as the heart of engineering practice. In other words, for Crawley, et al, the essential task of engineering is to design and implement solutions that have not previously existed (Crawley, et.al. 2008). The purpose of engineering education, according to Crawley et.al, is "to provide learning required by students to become successful engineers, that is, technical expertise social awareness and a bias toward innovation" (Crawley, et. al. 2008: 1). The Conceive-Design-Implement-Operate (CDIO) approach which Crawley et.al promote builds on stakeholder input to identify the learning needs of students in a program and construct a sequence of integrated learning experiences to meet those needs. The CDIO initiative, according to Crawley et.al, was launched in the year 2000 as a major international project to reform undergraduate engineering education.

Engineering Curriculum and Curriculum Development Process

The Accreditation Board for Engineering and Technology (ABET) in the U.S. case, refers to an 'Approved Engineering Curriculum' as 'any curriculum under ABET accredited engineering program leading to a baccalaureate degree in engineering'. According to ABET, it is a program leading to a four-year degree or a baccalaureate degree in technology (ABET).

Many writers in the area of engineering education point out that over the last fifty years engineering curricula have been based largely on an 'engineering science' model (Lattuca et al. 2009; Dym, et.al. 2005; Prados, 1998; Felder,). In this model, engineering is taught only after a solid basis in science and mathematics, of which the first two years are devoted primarily to the basic sciences. Such curricula, however, have not been without challenges since the 1950s. Few among other challenges were that engineering graduates who were the results of such curricula were perceived by industry and academia as being unable to practice in industry because of the change of focus from the practical (including drawing and shop) to theoretical (Lattuca, 2006: 5; Dym, et.al. 2005: 103). Hence, what is now identified as the "capstone (design) course" which eventually became the standard academic response which involved projects devised by faculty to industry- sponsored projects and where companies provide "real" problems, along with expertise and financial support. The infusion of first-year design courses that dubbed "cornerstone (design) courses" in 1990s and was motivated by an awareness of the curricular disconnect with first-year students who often did not see any engineering faculty for most of their first two years of study. During this period first-year project and design courses emerged as a means for students to be exposed to some flavor of what engineers actually do while enjoying an experience where they could learn the basic elements of the design process by doing real design projects.

Curriculum is also regarded as the product of the culture and values in which they are embedded (Haywood, 2005). According to Haywood this fact makes the transplantation of educational practices of one country to another is difficult. Haywood in addition identifies three paradigms of curricula in engineering, i.e., 'received', 'reflective' and 'restructuring' after Eggleston (1977). The received paradigm, according Haywood, describes a curriculum organization designed to meet the belief that there is a received body of understanding which is "given" even ascribed. It is predominantly nonnegotiable. Most engineering curricula are primarily of this kind, although some negotiation may be allowed, and to this extent they are reflexive" (Heywood, 2005). In other words, Petrina (2007) points out that "curriculum and instruction (C&I) are inseparable".

Even though the thinking and skill of "design" is closely associated with engineers, according to Rompelman and Graaff (2006), engineers seldom put their design skills into practice when they are faced with the task to develop a new course program or the innovation of an existing curriculum. According to Rompelman and Graaff (2006), the principles that can be used for any purposeful design can also be applied to curriculum. They suggest that the knowledge and skills that can be applied in the design of any purposeful project can be used for designing curriculum.

In engineering education, writing the aims and objectives or "outcomes" is said to be the starting point for curriculum development (Haywood, 2005: 19). Currently, engineering educators are required to state the outcomes. Many engineering educators who were inflected by Bloom's Taxonomy of Educational Objectives for cognitive domain continued to use it in its original form (Haywood, 2005: 19). Bloom's (1956) six levels of cognitive learning which include "Knowledge" which refers to the remembering of previously learned material, "Comprehension" which refers to the ability to grasp the meaning of previously learned material, "Application" the ability to use the learned material in new and concrete situations, "Analysis" the ability to break down material into its component parts so that its organizational structure may be understood, "Synthesis" the ability to put parts together to form a new whole, and

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 06, June-2023

finally "Evaluation" the ability to judge the value of material for a given purpose. According to Haywood, there is little doubt that the so called "outcomes movement" has its origins in The Taxonomy of Educational Objectives.

Curriculum Design in Engineering Education

As it has been seen earlier in this study, curriculum is taken as the formal mechanism through which intended educational aims are achieved. Achievement in the sense of this research refers to the students' construction of knowledge, skills, and attitudes based on their prior knowledge and are able to do what they are supposed to do. Curriculum incorporates the social, cultural and even political background of the program of a course. In the end, this formal mechanism includes two prime factors: instruction and learning and the issues of curriculum design have become a central paradigm in engineering education. Curriculum issues are inseparably linked to current thinking and action on educational concerns and reforms around the world. For instance, the imposition of General Agreement on Trade in Services (GATS) regime (Robertson, 2006) in the education sector necessitates enrichment and broadening of engineering curricula so that engineers will be better prepared to work in a changing global economy.

Accords & treaties like the Washington (1989), The Sydney Accord (2001), The Dublin Accord (2002), & The Bologna Process (1999) and others have been agreed upon to homogenize curriculum. Even though Ethiopia is not an official member of such groups at the moment and did not sign any of the treaties, it is obvious that it would be influenced by those ideas as long as curriculum development is backed financially by the government and technically supported by foreign advisors.

THE DEVELOPMENT OF EDUCATION IN ETHIOPIA

A Milieu for Engineering Curriculum Development Process

Richard Hooper (1972: 2) indicates "at a time of controversy, 'tradition' is quoted as a defense against change. An important way of setting the context within which curriculum can be studied is to analyze 'tradition", in this quotation Hopper calls for the attention of those who are involved in the study of curriculum, that they need to be concerned and analyze the inherited, established, or customary pattern of thought, action, or behavior to understand the present. This researcher thinks that this has to do well in the case of the Ethiopian education and curriculum development systems because he believes that the starting point for the Ethiopian education system is not the introduction of the western type modern education. Any curriculum research undertaking that neglects the previous experiences (which may be strong or weak) and focuses solely on the present, somehow misses some important elements that connect the past with the present or that may be drawn from the past. It is believed that "curriculum is socially and historically located and culturally determined (Hooper, 1971:2). The study of any curriculum development and practical undertaking does not develop in a vacuum but proceeds based on beliefs seldom made explicit about how people learn what human beings should be like, and what society is.

To begin with, it is a well-recognized fact that Ethiopia has a long history of education, teaching and learning, and assessment (Amare, 2005; Alemayehu & Lasser, 2012). The very existence of what we call education and its process, be it traditional, elementary, secondary, tertiary, or engineering, physics, chemistry, and others, is not a onetime development process and activity. It is a dynamic process, that grows and develops through time and nested within the culture of society and regenerate itself continuously from time to time as the society and its culture grows and changes. The beliefs that gave rise to the very existence of the education system in Ethiopia in general, and modern education in particular, and the process by which it was made to exist and develop together form the milieu of education in Ethiopia including engineering education. Hence, a brief look to the past evolvement of education in Ethiopia and its process may give us an opportunity to pick some elements that may facilitate or hinder our present action in our general or specialized education system and act upon it in accordance.

Ethiopia is a country located in North Eastern part of Africa. Its surface area covers a total of 1.125 square kilometer. Its climate varies from temperate in the highlands to tropical in the lowlands. Ethiopia is the second most populous country in Africa (World Bank indicators, 2010) next to Nigeria comprising a total population of 82.95 million. Of these, 48,561,390 are in the school age range of year 4 to 21 (Calculated from MoE (2010) Education Statistics Annual Abstract, 2002 E.C.). Of the total school age group, 28,750,782 are males and 19,810,608 are females. Different nations and nationalities residing within the country's territory are the core for the county's political, economic, and social structures that identify the country as the Federal Democratic Republic of Ethiopia. Ethiopia had its own education system, that served the Ethiopian Orthodox Church and the elite groups affiliated to it and which is different from the western type of modern education, even long before the introduction of modern education (Amare, 2005; Solomon, 2008).

Though the western culture of the natural and applied sciences seems to shape and be the dominant influence of the present modern education system in Ethiopia, it cannot be said that the western culture of education is the only influence that shapes the Ethiopian education system as a whole. This means even professional education such as engineering education and others, as part of the whole system are influenced by the influences that shaped the whole system of education. Anyhow, the intention in this part of the study is not to give an in-depth account of this line of argument; it is, just to indicate that the Ethiopian education system is influenced not only

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 06, June-2023

by the western culture of education but also by the Ethiopian culture of education.

Traditional Education

As it is mentioned herein above, the aim in this section of the study is not to give a detailed account and analysis of the traditional education. Rather, it is to give a brief highlight of the development of the Ethiopian education system and the practices of curriculum development evolved through time with the assumption of connecting the past with the present in terms of the concept of education, curriculum, curriculum development, and its implementation.

Scholars in the field of education inform us that Ethiopia has a long history of traditional education that began and subsequently developed under the realm of religion. It existed mainly as church education or as Koranic education. Though there were some evidences of what was included, in this type of education (Amare, 2005), the details of how it was organized, the bases for its content selection and sequencing, and the like seems to be less known and require more research. Nevertheless, Ethiopia "has had its own indigenous education and curriculum" (Solomon, 2008: 34; Amare, 2005) prior to the introduction of the western type of modern education and its influences are still visible in the education system in many respects.

The Development of the Ethiopian Modern Education

Many scholars, in one way or another, have dealt with the history, nature, and characteristics of the Ethiopian education. (Maaza Bekele, 1962; Girma Amare, 1967; Pankhurst, R. 1974; Teshome G. Wagaw, 1979; Amare Asgedom, 1995 and Tekeste Negash, 1996) are among many others in this regard. This, by no means, is not to claim for exhaustiveness. Ethiopia has a long history of education in general, and a form of education of different types and different levels peculiar to its own. The nature and the history of higher education, as related to Ethiopia are documented in Amare (2005). The concept and practice of structured traditional and formal education was well developed in certain parts of the country even before the introduction of the European type of education (Amare, 2005). In spite of this fact, indigenous education by large still remains to be an important transmitter of cultural identity from one generation to the next among many ethnic and linguistic groups (Derebssa, 2006: 62; World Bank, 2013). Formalized education in its traditional form, though not accessible for the large number of Ethiopians, existed since the fourth century A.D., and survived as a means for transmitting the long lived Christian and Islamic religious cultures and skills associated with them until the end of the19th entury. Since the beginning of the sixth century, the Ethiopian Orthodox Church had maintained a highly structured organized system of education. The Islamic religious education also existed and developed probably starting from the 7th century (Amare 2005). The education, especially the church education, provided throughout those earlier days, was mainly elite education (Saint, 2004; Teklehaimanot, 1999) which was linked to the Orthodox Church and it was meant to serve the functions associated with Christian religious tasks. Likewise, the Koranic schools that were attached to and promoted by the centers of Islamic faith used to have a parallel function in spreading the reading and writing of Arabic, the study of Islamic philosophy and law and the teaching of the Koran (Amare, 2005). Even though practical and accumulated wisdom and experiences were passed from generation to generation through the formal religious institutions mentioned herein above in certain limited parts of the country, in many of the social groups of Ethiopia the traditional/indigenous education process was also institutionalized in an age – grade system that ensured the continuity of experience and organization. The process in the introduction of programs and structures of teaching and learning that differed fundamentally from the traditional, religious based system was not really officially initiated until the very end of the nineteenth century. At the beginning of the twentieth century, the establishment and growing of urban seat of power or "the need to preserve a modernized centralized power" (Mekasha, 2005; Alemayehu & Lasser, 2012), and other factors, such as the arrival of foreign embassies and the beginnings of new features of commerce and manufacturing, combined together prompted and necessitated the beginning and promotion of a different pattern of education (Tekeste, 1996: 13).

The provision of modern education in Ethiopia officially began in the year 1908 with the opening of Minilik II School in Addis Ababa, marking a significant step in the history of education in the country. It had been followed with the additions of more schools soon after. The content of the curriculum, within the new school system included Amharic, Geez, Arabic, Italian, French and English (MoE, 1984). Simply by looking into such provision of education, it would not be difficult to understand what the emphasis of education was and what was needed by educating youngsters. The emphasis on language teaching clearly entails that the need was on communication skills. But here one could raise a mega question 'whose need was served by such curricula? And who steered the initiative to produce the curricula?' This researcher believes that the system established at that point in time had set the Ethiopian education context which still has an impact on our current education system in many ways. Such question might have been addressed by researchers in the field, if not, or as complementary note, this researcher would like to suggest the importance of conducting research that involves parents, students and the wider public with regard to the kind of education they need. How do parents judge the quality of a school these days in Ethiopia? And how do these parents judge their children's education and pay more money for it in the form of tuition fee? How do private schools attract students? Do the private schools attract students by emphasizing on language or on the sciences? In raising questions such as these ones and trying to find out answers, one may be able to come up with the knowledge of the impact of the earlier thinking of curricula to the present school system we have today.

The introduction of the Western (modern) education, from the outset, did not please a number of people and was not welcomed by the

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 06, June-2023

Ethiopian Orthodox authorities and their followers and inflicted resistance to it. Hence, the attempt of bringing change through the traditional models to modern and secular form of education, however, was not a simple task for those who tried to change (Alemayehu & Lasser, 2012: 53). After a serious conflict with the church authorities and their followers, an agreement was reached in 1907 to employ teachers of the Coptic faith to teach in the new system of education.

Its objective was to provide education that would equip the students who could serve the state in different sectors of the economy and other service areas at different levels and capacities. The need for having more contact with the outside world also became one of the significant stimulants for education and encouraged the introduction and use of the schools as a means for the creation of high-level interpreters and translators. In those early days, the content of the education provided within the schools focused mainly on communication skills and the essentials that were necessary to run the then new bureaucracy and the associated institutions.

For the first time in Ethiopian history, a director general of public education was appointed in 1929 and it was elevated to the status of Minister in 1930. At that point in time there was no physical system capable of supporting the systematic growth of educational services. The system remained dependent on personal funds in spite of a decree in 1930 allocating a 2% of tax revenue to education. However, the idea of centralization and control, in short, the formulation of an education system in its modern form began and continued slowly to take shape. Committees were organized to plan and shape the system to meet the growing needs of the community for education (year book, 1951-53). Up to 1945 it was a period of increasing the number of elementary schools. At that time parents also began to realize the importance of public education and students were no more asked to come to school as it were in the years before then (year book, 1951-53).

The first high school, the Hailesellasie I Secondary School, was formally inaugurated in 1943 and teachers who would teach at that level were provided by the British Council (Trudeau, 1968). During that time, there were many teachers teaching in the elementary schools and almost all of them were foreign teachers. Evidences reveal that there were no definite programs of studies in the education system at that time, but secondary schools were better unified because they were preparing students for the school-leaving certificate along the general lines of the London Matriculation (Trudeau, 1968). In 1952 there was a relatively strong network of the then existing four hundred elementary schools and three colleges.

In the years 1951-1953 there were six secondary schools. The curriculum for this level was adopted by the Ministry of Education in the year 1951-1952, and it became operational in all of the secondary schools. Entrance to the secondary schools was based on the elementary school leaving examination. The courses provided at the secondary level were primarily for academic preparation of youngsters for the London Matriculation, which was later changed to General Certificate of Education. Students who were successful in the London Matriculation or the General Certificate of Education either went abroad for higher education (in the earlier years) or continued at the University College of Addis Ababa, which was established in 1950. Seen in general, the education provided in the country from 1940s until the end of the 1960s, as observed by Tekeste (1996: 15) “could be described as an elitist system”.

In 1955 there was a structured government school system that comprised three main divisions of elementary – covering grades one to eight, secondary – covering grades nine to twelve, and higher level. At about the same time thoughts of ”Long – term Planning” (MoE, 1955) appeared in the Ethiopian education system accompanied with the establishment of the Long-Term Planning Committee that comprised four Ethiopians and seven foreigners. The committee was authorized to undertake a survey of the then existing system, the schemes of work and academic standards and to make recommendations for possible reorganization (The Long-Term Planning Committee, 1955 (1947 E.C.)). This committee was also authorized to call for written and personal reports from administrators, school directors, teachers, and others engaged in or concerned for Ethiopian education.

The Board of Education, to whom the report was presented, after having looked into it and proposed certain amendments, returned the report to the committee. The committee then readily accepted the amendments and included in the final version of the report. Finally, the board informed the committee that it was prepared to accept in principle the revised recommendation. At the same time the committee was also informed and authorized to consider the details of the organization, curriculum, and staffing with a view of implementation. While the agenda and the view on the provision of primary and secondary education were predominantly on a restrictive and limiting position, and while it was still in a fluid state, paradoxically, the need for considering the establishment and development of higher education started to come into sight.

Higher Education

The provision and practice of modern higher education in Ethiopia is relatively young, compared to the actual beginning of western type modern education within the country. On top of the long existed traditional education and the then yet developing primary and secondary education, Ethiopia also introduced higher education and began teaching students at that level in 1950 (AAU, 2008; Amare,

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 06, June-2023

2005). Though there were many Ethiopians who went abroad (Amare, 2005) before the year 1950 there was no evidence of any Ethiopian (at least to knowledge of this researcher) who actively and decisively played a significant and knowledge-based contribution for the establishment and materialization of higher education system in Ethiopia.

Because of the felt need for higher education from the government side, the establishment of higher education was decided by the Ministry of Education of Ethiopia from the outset (Trudeau, 1964). As a response to the emperor's demand for a kind of policy he should follow in establishing the secondary and vocational sections of Tefari Mekonene School, Dr. Matte proposed for the establishment of higher education (Trudeau, 1964). Mattee suggested the development of a university that comprised Engineering (Civil, Mechanical, Mining), Agriculture, Science, Botany, Geology, Mineralogy and Geography. Mattee also suggested the opening of medical school in conjunction with that of the school of sciences. Hence, a committee on founding of higher education was set in 1949 and this committee, within the same year, recommended the creation of a four-year liberal arts college leading to B.Sc. and B.A and comprising two faculties—the Faculty of Science and Faculty of Arts. On the bases of the recommendation, the college was established in 1950 and was named as Trinity College which later, after eight months, changed to Addis Ababa University College (AAUC). Matte was appointed as the founding president of the first higher education institution. The faculty of Science was considered as the most important and was made to offer courses in Agriculture, Mathematics, Physics, Chemistry, and Biology. On the other hand, the Faculty of Arts was made to offer courses in Administration, Education, and Social Sciences.

Even though the distinction between them was not flagrantly supported with an in-depth and comprehensive study, the Ethiopian higher education system had gone through "three major changes" (Wuhibegezer, 2013: 45). The first of the changes, was "the phase of an elitist education system under the traditional monarchy", the second phase was the change that was imposed by the "military rule where ideological control penetrated into the education system" and the third one was the higher education system "under FDRE" (Wuhibegezer, 2013: 45) where expansion of higher education become too evident. These changes were mainly associated with government changes. It is true that these changes have been major externally proposed changes that influenced the higher education system in many ways. But these alone do not suffice to be the only measures for the changes in higher education. Of course, that is, what is better known than any other changes that might have taken place within the higher education institutions. If we push the quest a little further and ask questions like: is the present higher education significantly different from the elitist education that was phased out? The answer we may get could probably be one of discouragement.

The Curriculum of Higher Education

In the preceding part it has been pointed out that the Ethiopian higher education system was established in 1950 which means 65 years back. Mention has also been made that the higher education at the beginning was influenced by the North American concept of Liberal Arts College. The curricular content was a Liberal Arts type similar to that of Jesuit College of North America. Liberal Arts and Sciences as defined by the State Education Department/the University of the State of New York (2003) refers to "courses of a general or theoretical nature that are designed to develop judgment and understanding about human beings' relationship to the social, cultural and natural facet of their total environment". This may be regarded as a landmark for laying down one of the foundations that characterizes the Ethiopian higher education curriculum. As it has been indicated earlier in this study the Ethiopian higher education system has undergone three changes associated with government changes. Though these changes witness the changes in the education system in general, research in higher education seem to be limited and fail to address the detailed changes that might have taken in the perspectives and ideologies that shaped curriculum and curriculum development in the realm of higher education.

Engineering Education

The provision of engineering education had started and existed within the Ethiopian education system since the year 1953 and it was administered by the Ministry of Education of Ethiopia at the beginning, for some years (Faculty of Technology, (1979-80 G.C.; Addis Ababa University Golden Jubilee 1950-2000, Agenda). The first classes of engineering were started and continued in what was called engineering college which was situated within the compound of the Technical School of Addis Ababa up to the year 1965. The first two years of its beginning was devoted to provide a two-year intermediate engineering studies which prepared students for the completion of a degree level study abroad. Soon after, in 1955 a four-year degree program was commenced and upon completion of the program the first B.Sc. degrees were awarded in civil and industrial engineering in 1958.

However, in 1959 industrial engineering was made to phase out, and on the other side, expansion took place by the inclusion of electrical and mechanical engineering on the then existing programs. The consolidation of the Building College, (which was formerly known as the Ethio-Swedish institute of Technology) in 1961 was another side of the expansion of engineering education in Ethiopia. The Ethio-Swedish Institute of Technology was established in 1955 and initially it used to have a Diploma program in Building Technology which continued until it was finally changed and upgraded in 1957 to four-year degree program. The duration of the study of the engineering programs was four years and prolonged to five years on the grounds of shortages in qualified staff and the

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 06, June-2023

inadequacy of laboratories. But later in 1978 it was again changed to four years. Although much was not known about how the content was selected, the specific structure of the curriculum and the details of the practices (at least to the knowledge of this researcher), efforts were also made to overhaul the curricula of all the programs. Along with the overhauling of all the programs, the five-year engineering programs were again changed to a four-year program and the three-year advanced diploma program of Building Technology to two-and-half years.

Moreover, the provision of engineering education was extended to the relatively new institutions such as Arba Minch Water Technology Institute, which was originally established in 1986 under Water Resource Commission, and which was later transferred to the Ministry of education, Jima University, Makalle University, Bahir Dar University, and Hawassa University.

Currently, engineering education is provided in a number of engineering education institutions and universities within Ethiopia guided by the ECBP reform initiatives that took place since the year 2005. The general goal of the ECBP was, "improving the competitiveness of local manufacturing and construction industries and creation of employment opportunities for Ethiopian youth and thereby improving the standard of living of the society" (Bayou et al. 2006: 18). The university specific goal which was regarded as one of the strategies of attaining the ECBP's general goal was "improving studies in technical and managerial fields including the studies and training of vocational school teachers" Bayou, et al 2006: 18). This was further detailed to include the following specific objectives.

- Develop and implement proposals for re-organization of university structure in order to acquire more decentralized, effective and cost-conscious administration;
- Prepare and implement professional profiles for Architecture, Construction management, Urban and Regional Planning, Civil Engineering, Chemical Engineers, Electrical and Computer Engineers, Mechanical Engineers and revise and implement graduate and post graduate programs.
- Conduct human resource development in line with new curriculum.
- Establish partnership between Ethiopian and foreign universities/departments for all kinds of cooperation.
- Establish and strengthen University-Industry linkage promotion.
- Prepare and implement infrastructure upgrading requirements of university facilities for selected universities/departments.
- Establish a system of E-learning and develop and implement a concept for IT-based library and build models.
- Develop and implement comprehensive practice-oriented concept of TVET Teacher Studies and a demand-driven HRD scheme (Bayou, et al. 2006, 18-19).

The specific goal of the ECBP's university reform was to acquire a practice and demand oriented higher education in the wider field of engineering disciplines that can actively and innovatively contribute and support the industrial development of Ethiopia. This model, as it is pointed out in Chapter one of this dissertation, is closely associated with human resource development that has to do with improving working systems that would help the industry and the manufacturing sectors within the country.

CURRICULUM SYSTEM BASED ON CDIO

The National Academy of Engineering in the United States named 14 "grand challenges" for engineers to overcome in the twenty-first century. "Sustaining life on Earth," "Living secure from threats," "Promoting healthy living," and "Living and learning with joy" are some of the issues. According to Al-Atabi (7), a program that prepares students to handle major issues should include research experience, an integrated curriculum, entrepreneurship training, a global perspective, and service learning.

To better equip engineering students with technical knowledge as well as communication and professional skills, the CDIO approach employs active learning tools such as group projects and problem-based learning. Furthermore, the CDIO Initiative provides resources for member university instructors to improve their teaching abilities.

Engineering education programs throughout much of the 20th century offered students plentiful hands-on practices. Accomplished and experienced engineers taught courses that focused on solving tangible problems. In due course of time, due to rapid advancement in science and technology, engineering education drifted towards the teaching of engineering science. Teaching engineering practice was increasingly de-emphasized. As a result, industries in recent years have found that graduating students, while technically adept, lack many abilities required in real-world engineering situations.

There appears to be an irreconcilable conflict between two growing needs in undergraduate engineering education today. On the one hand, there is the ever-expanding body of technical knowledge that graduating students are expected to possess. On the other hand, there is a growing recognition that young engineers must have a diverse set of personal, interpersonal, and system-building knowledge and skills in order to function in real engineering teams and create real products and systems. (8)

Innovative solutions that do not overburden students and lectures are required to resolve this conflict. To address the increasing gap between scientific and practical engineering demand and to meet the global requirements of professional Engineers, the CDIO

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 06, June-2023

curriculum was introduced. (9). The CDIO initiative promotes fundamental engineering education within the context of the product-system lifecycle, which can be thought of as having four metaphases: conceiving-designing-operating-implementing (10). This is typically accomplished through the use of active, hands-on, and project-based educational approaches in order to achieve integrated learning, in which disciplinary knowledge and CDIO skills are acquired concurrently. The CDIO initiative's philosophy is outlined by the 12 standards and syllabus it uses.
Gustafsson et al. (11) presented a study of four first-year engineering introductory courses from different CDIO Program universities. The courses were discussed, with an emphasis on the student projects, and it was demonstrated that these introductory courses are an ideal testing ground for the CDIO approach, where new ideas can be tried, developed, and assessed to support CDIO skill learning. Al-Atabi and Chin (12) and Al-Atabi (13) used an introductory design course as the centerpiece to integrate the curricula of a first-year mechanical engineering undergraduate course.
As simple as it appears, this approach necessitates a high level of coordination on the part of the lecturers delivering the relevant modules in order to effectively achieve the required objectives. This paper describes the use of the "theory of machine and mechanism" module, which is offered in the second semester of the third year of a five-year Mechanical Engineering course, in conjunction with a theory-based module, to provide an integrated Project Based Environment that addresses the CDIO standards and syllabus without introducing any major changes to the syllabus of the theory-based module.
There are two sections of class of forty-five students was divided into four groups, and each group was tasked with developing, designing, implementing, and running a project related to the mechanism of machinery module. Throughout the course, students demonstrated a high level of engagement and motivation while learning more about real about mechanism of machinery.
According to Kamp (15), contemporary engineering curriculum usually place too much emphasis on technical knowledge and processes while ignoring the socio-economic environment in which technological solutions are only part of the answer. Creative thinking, decision-making, leadership, a global mentality, and multidisciplinary thinking are among the important characteristics listed by Kamp for future engineers. However, Kamp determined that the most crucial capability of future engineers is a constructive attitude toward life-long learning.

For the first version of the CDIO syllabus, Crawley et al. (16) gave a concise critique of the development ideas. The critique suggested that knowledge and abilities relating to innovation, invention, sustainability, international factors, dialoguing, leadership, and entrepreneurship should be given a higher profile. As a result, the CDIO syllabus has undergone certain revisions, including the addition of new sections on "Leading engineering initiatives" and "Engineering entrepreneurship." The CDIO standards, on the other hand, were not changed.

CDIO is appealing to institutions all around the world because of its relative advantages, interoperability, simplicity, trial-ability, and observability (17). The CDIO framework was implemented for three reasons: (1) to make engineering education more real, (2) to provide a systematic methodology for instructional design, and (3) to encourage greater design and innovation in the curriculum (18).

CDIO implementation requires both top-down and bottom-up approaches to be successful. The top-down methodology can be a decision made by the management team to embrace the CDIO framework in order to ensure that the institutional vision and educational development goals are compatible. The challenges of CDIO implementation, on the other hand, include a shift in mindset, faculty buy-in, dispute, and duplicate work in terms of the national qualification standard and accreditation. To overcome these challenges, the bottom-up method is suggested (19). With the involvement of faculty members, program committees, and department heads, the changing process raises an intrinsic motivation, a strong commitment, ownership, and value of CDIO (20).

The CDIO Syllabus and CDIO Standard are curriculum design and development guidelines. Several renowned colleges have developed their own models, strategies, and processes for implementing a plan to restructure or build a new curriculum. One of the CDIO pioneers, Linköping University (LiP), incorporated CDIO into their Applied Physics and Electrical Engineering, Electrical Systems Engineering, Media and Communication Technology, and Logistics Engineering departments at an early stage. Faculty, industry, and students are among the parties involved. A survey of the CDIO syllabus, an introduction of LIPS models for design-build project management, and final approval of CDIO ideas with a strong focus on the graduates to become professional engineers were all part of the program development (21).
The management team at the Technical University of Denmark (DTU) made the choice to adapt CDIO. A benchmarking approach was carried out on the existing Chemistry and Biotechnology curriculum to determine where CDIO elements were already present and where improvements could be made. To obtain the competence matrix interpretation for CDIO Syllabus benchmarking, a color mapping technique with the integration of modified Bloom's Taxonomy and the introduce-teach-use ranking was recommended (22)

Later, Gunnarsson et al. (2008) compared LiP and DTU on a large-scale implementation utilizing the CDIO Syllabus to create program goals and learning outcomes. The work included local CDIO Syllabus adjustments to fulfill national higher education laws, an introduce-teach use (ITU), and skill progression matrix, among other processes and tools for educational program creation.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 06, June-2023

Armstrong and Niewoehner (23) developed an improved CDIO technique to help students develop the abilities and traits needed to become professional engineers. A tailored syllabus, a stakeholder survey, an application of Bloom's Taxonomy, and consultation with accreditation standards were used to develop program learning outcomes. Program learning outcomes, disciplinary learning outcomes, an existing curriculum benchmark with ITU, measurable qualities, a skills development plan, and CDIO requirements can all be taken into account while planning the integrated curriculum.

At Shantou University in China, a curriculum reform based on the CDIO framework was centered on an integrated, holistic approach to addressing changing industry demands. Five engineering programs were redesigned using a design-directed framework, with a special focus on Ethics, Integrity, and Professionalism, resulting in an EIP-CDIO effort at the school (24)

Based on the CDIO syllabus and the Engineers Australia National Generic Competency Standards, Popp and Levy (25) established a method for mapping curricula against any generic framework. The new process made mapping easier and reduced the amount of repetition in academic inputs.

Hellinga-Brink and Kok (20) used track classification to manage a CDIO implementation for 12 programs. The fast track was for programs that had already implemented CDIO, the drawing board was for programs that needed to restructure their curriculum, and the quality track was for programs that employed CDIO as a tool for quality improvement.

Support from management, tight collaboration of drivers, a modified CDIO syllabus by early adopters and education professionals, and CDIO standards interpretation for the local context are all critical success factors for CDIO adoption at Singapore Polytechnic (SP). SP, as an Asian regional leader, provides expertise to assist faculty in implementing the CDIO framework with the SP 5-component model, which includes Introduction to CDIO Teaching and Learning Framework (Standard 1), Designing an Integrated Curriculum (Standards 2, 3, 7 and 11), Conceiving and Designing Innovative Products and Systems (Standards 4, 5 and 6), Designing Active and Experiential Learning Experiences to enhance students learning (Standard 8), and Programme evaluation to assess program effectiveness (Standard 12) (19)

Conclusion

For CDIO deployment to be successful, top-down and bottom-up strategies are both necessary. The management team may choose to use the CDIO framework and use the top-down methodology to make sure that the institutional vision and educational development objectives are in line. On the other hand, difficulties implementing CDIOs include a mentality change, faculty buy-in, disagreement, and duplication of effort in terms of national qualifying standards and accreditation. The bottom-up approach is recommended as a solution to address these issues. The changing process increases an inner motivation, a strong commitment, ownership, and value of CDIO with the participation of faculty members, program committee members, and department heads.

Acknowledgement

All for my Beautiful wife Mekdes Bedada.

REFERENCES

[1] *Grand Challenges for Engineering and Development of CDIO Skills.* Al-Atabi, M. MA, USA : Cambridge, 2013. Proceedings of the 9th International CDIO Conference.
[2] *The CDIO syllabus: A Statement of goals for undergraduate engineering education.* Crawley, □ E.F.□. 2001, Retrieved on August 2009 from http://cdio.org/cdio_syllabus_rept/index.html.
[3] *Rethinking engineering education: The CDIO approach (1st Ed.).* Crawley, E.F.; Malmqvist, J.; Ostlund, S.; and Brodeur, D. 2007, Springer .
[4] *Benchmarking engineering curricula with the CDIO syllabus.* . Bankel, J.; Berggren, K.F.; Engstrom, M.; Wiklund, I.; Crawley, E.F.;Soderholm, D.; El Gaidi, K.; and Ostlund, S. 2005, International Journal of Engineering Education.
[5] *First-year introductory courses as a means to develop conceive–design–implement-operate skills in engineering education programmes.* Gustafsson, G.; Newman, D.J.; Stafström, S.; and Wallin, H.P. 2002, Proceedings of the 30th SEFI Annual Conference, .
[6] *A case study in project based learning using flow visualisation.* Al-Atabi, M.T.; and Chin S.B. 2007, Journal of Engineering and Science Technology (JESTEC), pp. 290-297.
[7] *The use of project based learning as a first year integrated teaching and learning medium.* Al-Atabi, M.T. 5th International CDIO Conference.
[8] *CDIO Curriculum For Mechanical Engineering Undergraduate Course.* Mushtak Al-Atabi, Abdulkareem Sh. Mahdi. 2011, journal of engineering science and tehnology.
[9] A., Kamp. *Engineering Education in a Rapidly Changing World – Rethinking the Mission and Vision on Engineering Education at TU Delft.* Delft, The Netherlands : Delft University of Technology, 2014.
[10] *Rethinking Engineering Education.* Crawley, E., F. Malmqvist, J., Östlund, S., Brodeur, D., & Edström, K. 2014, The CDIO Approach, 2nd edition. New York: Springer-Verlag.
[11] *why universities want to join CDIO?* kontio, J. canada : university of calgary, 2017. 13th international CDIO confrence.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 06, June-2023

[12] *Application of CDIO in Non-engineering Programmes – Motives, Implementation and Experiences.* . Malmqvist, J., Leong H., Kointio,J., Doan,T.T.M. Turku, Finland. : Turku University of Applied Science, 2016. he 12th International CDIO Conference.
[13] *Comparative Study on CDIO Implementation in Selected ASEAN Countries.* Lee, L. Lee, L., Kuptasthien, N., Tien, D.B., Saad, N.H., Leong H. Chengdu, Sichuan PR China. : Chengdu University of Information Technology,, 2015. The 11th International CDIO Conference,.
[14] *Implementing CDIO in Twelve Programs Simultaneously Change Management.* Hallenga-Brink, S. and Kok, O. . Turku, Finland : Turku University of Applied Science, 2016. The 12th International CDIO Conference.
[15] *Development of Three Bachelor Programmes at Linkoping.* Bjerner, K. and Granath, S. Ontario, Canada : Queen's University,, 2005. The 1st Annual CDIO Conference.
[16] *CDIO in Chemical Engineering Education.* Vigild, M.E., May, M. and Clement, K. . Massachusetts, USA : MIT, Cambridge, , 2007. The 3rd International CDIO Conference.
[17] *The CDIO Approach to the Development of Student Skills.* Armstrong, P. and Niewoehner, R. . Gent, Belgium : Hogeschool Gent, 2008. The 4th International CDIO Conference.
[18] *Curricular Reform Based on the CDIO Initiative in Shantou University.* Gu, P., Shen, M. and Lu, X. Massachusetts, USA : MIT, Cambridge, 2007. The 3rd International CDIO Conference.
[19] *The Development of a New Efficient and Cost-effective Mapping Process to be Used with Generic Frameworks with the Aim of Curriculum Improvement.* Popp, A.B. and Levy, D.C. . Montreal, Canada : Ecole Polytechnique, 2010. The 6th International CDIO Conference.